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How Preservice Elementary Teachers Develop Their Personal Philosophies About Science Teaching: The Role of Informal Science Approaches

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Abstract: The purpose of this case study was to explore how (if in any way) three informal science approaches as part of a teacher preparation program could shape preservice teachers' personal philosophies of science teaching and learning. Data were collected in a period of two academic semesters in the context of an elementary methods course through the following sources: science autobiographies, personal philosophies about science teaching, drawings about their most memorable and least memorable experiences of science, three reflective journals about the three informal science experiences (i.e., working with scientists, field, science festival), lesson plans, responses to final exam questions, observations, and semi-structured interviews. The participants were 16 preservice elementary teachers, seven males and nine females. Open coding techniques were used to analyse the data in order to construct categories and subcategories and eventually to identify emerging themes. The outcomes of the analysis showed that the inclusion of informal learning in teachers' preparation has the potential to support preservice teachers' in reconstructing their ideas about science and science teaching in ways that are aligned with reform efforts emphasizing student engagement, working with scientists, and utilizing out-of-school spaces for learning.

Keywords: *Informal science; Teacher education; Science education*

Introduction

A review of the literature showcases the significant role and value of informal science environments, such as science centers, zoos, botanical gardens, community places and others, on both children's and adults' learning (Avraamidou & Roth, 2016). Besides their potential to support science learning, informal science environments offer possibilities to present science as a more interesting and attractive topic because of the correlation of science with everyday life (Bevan & Dillon, 2010). At the same time, as opposed to formal learning, informal learning offers more attractive frameworks, which can change

depending on learners' interests and needs (Fallik, Rosenfeld & Eylon, 2013). Despite the advantages of informal learning, researchers do not want to minimise the significant role of formal learning that takes place in schools. On the contrary, researchers emphasise the importance of coexistence and cooperation between the two different types of learning so we can aim for better learning outcomes (Anderson, Lucas & Ginns, 2003). Researchers have emphasised how the collaboration of formal and informal learning can offer importance benefits for students' science learning (Anderson, Lucas & Ginns, 2003; Education Development Center, 2014; Krishnamurthi & Rennie, 2013; Murmann & Avraamidou, 2013). Contemporary

approaches in science teaching and teachers' professional development showcase the significant role of informal learning environments in supporting the development of content knowledge, the knowledge of the nature of science and the work of scientists, the development of positive attitudes towards science and the support of learning through scientific inquiry (Avraamidou, 2014). The combination of formal and informal science approaches provides the participants with knowledge, understanding, modulation of thinking, different behaviours and actions, and additional abilities that they had not previously acquired. It also provides opportunities for science and technology education (Krishnamurthi & Rennie, 2013). Over the last 20 years quite a few researchers have examined the role of informal science on teacher learning and development (Anderson, Lucas & Ginns, 2003, Anderson, Lawson & Smith, 2006, McNally, Blake & Reid 2009). Built upon this framework, the purpose of this study is to explore how three informal learning approaches can affect preservice teachers' personal philosophies about science teaching. The research question that guided the design of this study is the following: *In what ways (if any) has their engagement in three informal science learning experiences shaped a group of preservice teachers' personal philosophies about science teaching and learning?*

Theoretical Underpinnings

Almost all individuals have memories of family visits to zoos, aquariums, planetariums, and museums, and we have always found something that was of our interest and curiosity. Such visits have taken place for at least two hundred years (Fenichel & Schweingruber, 2010). Regardless of the reason for these visits, it seems that the concept of science is

known to them, interesting and memorable (Bevan & Dillon, 2010). Thus, in the last few decades researchers have shown a scientific interest and have started studying what and how visitors learn, but also whether their experiences in informal environments enhance their identity as learners of science (Fenichel & Schweingruber, 2010). According to the Informal Science Education Ad Hoc Committee of National Association for Research in Science Teaching (Bevan & Dillon, 2010), learning occurs from our experiences in the real world, through a variety of appropriate physical and social content. Likewise the, National Education Standards published in North America emphasize how science museums and scientific centres can help the understanding of science, and encourage students to investigate their interests outside the school context (Bevan & Dillon, 2010).

Informal science learning has broadly been defined as the learning that occurs outside the school context and as self-acting, voluntary and driven by the need and interest of the learner. It's the learning that deals with the learner's whole life (Rennie, 2014). In contrast, when researchers refer to formal learning, they refer to education which is established by law and all goals, and mentors are defined by education policy makers (Fallik, Rosenfeld & Eylon, 2013). Furthermore, formal learning occurs only inside the classroom and the leader is the teacher; formal learning is forced, structured, evaluated and has a limited length (Hofstein & Rosenfeld, 1996; Stocklmayer, Rennie & Gilbert, 2010).

Various educational institutions such as universities, colleges, schools and several companies use informal learning. They use it in an inside or outside context (Fallik, Rosenfeld & Eylon, 2013). More specifically,

informal learning occurs in museums, (Hofstein & Rosenfeld, 1996; Rennie, 2014), scientific centers, aquariums, botanical gardens (Rennie, 2014), zoos (Hofstein & Rosenfeld, 1996; Rennie, 2014) and planetariums (Rennie, 2014). Also, it can take place through school trips, within or outside of school context (Hofstein & Rosenfeld, 1996; Rennie, 2014), family visits (Rennie, 2014) or discussions with friends (Stocklmayer, Rennie & Gilbert, 2010) or scientists (Fenichel & Schweingruber, 2010). Furthermore, it is also offered through afternoon and voluntary programs for adults and children, scientific festivals while it can also be implemented through various daily activities, such as playing, doing chores, etc. (Rennie, 2014; Stocklmayer, Rennie & Gilbert, 2010)).

Methods

Context

In this study, the 16 participants were enrolled in a teacher preparation program at a university in Southern Europe. Preservice teachers enrolled in this preparation program are required to take 3 science content courses during the first three years of their studies and an elementary science method course in the last year of their studies. The data of this research were collected as part of the elementary method course for which one of the authors served as the instructor during the fall semester of 2016, entitled “Teaching Science at the Elementary School”. As part of the course, the preservice teachers were involved in three specially-designed activities which are also placed in informal science contexts: (a) working with a scientist; (b) carrying out a field-study; and, (c) participating in a science festival. For the purpose of providing the participants with opportunities to work closely with scientists, the students had the opportunity to work

with three different scientists, a biologist, an immunologist and a chemist. The scientists were chosen purposely as to contradict stereotypical characteristics ascribed to scientists. Two of the scientists were female and the other was male. Also, all of them were young, social, dressed casually and were very informal and approachable. During the first part of the meeting, the scientists visited the classroom and informed the preservice teachers about the science they serve and their professors. During the second part, the class visited their laboratory, and the preservice teachers had the opportunity to see how a laboratory looks like and what tools scientists use. The preservice teachers also had the opportunity to carry out simple experiments, such as DNA extraction. In the second informal science experience, preservice teachers interacted with primary education students in an educational environmental centre, and together, they engaged in a lesson about the city and peripheral parks, and was based on an outdoor field study with data collection about the local fauna. This experience gave preservice teachers the opportunity to watch how an educator of an environmental centre can adopt the role of the teacher to help students learn by experiential learning. In the third informal science experience, preservice teachers participated in a science festival, which brought together students of different ages from different parts of the country for the purpose of engaging in experimentation with science. During the festival, preservice teachers had the opportunity to prepare their experiments about various topics by following the steps of the scientific research, and then demonstrate them to young children of different age groups.

Design, participants, data collection and analysis

The study followed a qualitative case study research design since it explores a group of pre-service teachers in specially designed activities in the context of informal learning settings. The design of the study was based on an in-depth data collection involving multiple sources of information rich in context (Creswell, 2007). As a qualitative study, it aims to examine the meaning of phenomena, based on the perspective of the people involved in the study, while examining in depth, the attitudes of people, highlighting the varied meanings of their social activity (Merriam, 2009). A multiple case study is an empirical research, which explores a contemporary phenomenon within its real context (Yin, 2003a).

The participants of the study were 16 preservice teachers, seven male and nine females, who enrolled in the science methods course at a university in Southern Europe. After the end of the semester, four of them were purposely selected to participate in semi-structured interviews, where they talked about their experiences during the method course. Two of them were females and two were males. At the end of the methods course, three of these preservice teachers were selected to participate in the last phase of data collection, which involved the observation of practical applications in school experience.

The data were collected through a period of 2 academic semesters, from September 2016 to January 2017, and from February 2017 to May 2017. In order to explore the impact of these three informal science experiences, data were collected from the following sources: autobiographies about science, three reflective journals about the three informal science experiences (scientists, educational-environmental centre, science festival), lesson plans, and answers to final exam questions. After the end of the semester, data were collected through semi-structured interviews with 4 students, where we discussed how the method course and more specifically, the three informal science experiences influenced their ideas about science teaching and learning. During the spring semester of 2017, the students who had participated in the method course the previous semester, participated in the school experience, where they had to teach all the lessons that provide primary education in Cyprus, including science. At this stage, data were gathered through classroom observations of the participants' teaching practices, lesson plans, and semi-structured interviews following classroom observations (see Table 1).

Table 1.

Description of Data Collected.

| Data Source | Description | Length/ Duration |
|--|---|---------------------|
| Biographical statement in relation to science | Write your biography in relation to science. Describe any events, experiences, activities, readings, films, interactions, etc. Identify people that were critical to your view of science. Indicate both formal and informal experiences. Describe your philosophy of science teaching and learning, use examples when necessary to justify your claims about how you think students learn best science. Draw yourself teaching science in the future and provide a narrative that explains the classroom settings and approaches used. | 3 pages |
| Reflective journal about the interaction with scientists | How did you feel following your interaction with the scientists? What were your perceptions about scientists before your interaction with them? How these perceptions change (if they change) after your interaction with them? | 2 pages |
| Reflective journal about the visit to educational-environmental centre | How did you feel following the visit in the educational-environmental centre. Write few words about your interaction with students during the field study. How did this make think of yourself as a future teacher? What is your opinion about this specific informal practice? | 2 pages |
| Reflective journal about the science festival | How did you feel following participation in the science festival? Write a few words about your interaction with students during the field study. How did this make you think as a future teacher? What is your opinion about this specific informal practice? | 2 pages |
| Lesson plans | Various topics Required question: Describe your philosophy of science teaching and learning, use examples when necessary to justify your claims about how you think students learn science best Choice 3 of 4 questions: - Suppose you applied the "Drawing of a Scientist" activity to your class (6th grade) and discovered that your students have stereotyped notions about the characteristics and nature of the work of scientists. Describe specific teaching practices that you would use to support the reshaping of your pupils' perceptions. | 3 pages |
| Final Examination | - Taking into account the visit to the educational-environmental center, report your opinion on the importance of informal learning environments in Physics science teaching. - Recalling your entire process of preparation, organization and participation in the science festival, report your opinion on the importance of student participation in science festivals. - Remember the visit of the scientists to the lesson and take into account your personal experiences, to report how the contact of students with real scientists can enhance knowledge, but also remodel their attitudes and perceptions towards Science as a branch, but also as a workplace. | 8-9 pages |

Table 1 continued

| | | |
|--|--|--------------|
| Interviews before school experience | Talk to us about yourself and your family, and any experiences you had with science (emphasis on informal experiences). Talk to us about your experiences with science as you were growing up (emphasis on formal experiences). Tell me about your experiences with science at university (i.e., content courses, methods courses, assignments, instructors). | 4 hours long |
| Classroom observations (school experience) | Detailed descriptions of specific student incidents and reactions that occurred during the practical implementation of informal learning by students in their schooling experience. | 24 pages |
| Interviews after school experience | Tell me what you hope to learn from your field experience. What are your thoughts, concerns, and feelings in terms of the transition from university to field experience? Talk about your experience. Share both positive and negative events. What difficulties did you face? How was the experience of your first year of teaching, how does your classroom look, in what ways do you teach science and how does that differ from your personal science teaching philosophy? | 3 hours long |

For the data analysis, we used an inductive analysis (Patton, 2002). In doing so, we went over the data multiple times for the purpose of identifying specific patterns, themes and categories that relate to the data of each individual involved in the research (Patton,

2002) We chose to carry out in-vivo coding for the purpose of developing categories and subcategories, and identifying various emerging themes (Coffey & Atkinson, 1996), as shown in Table 2.

Table 2.

Example of Data Analysis Procedures.

| Category | Sub-category | Code | Sample data |
|---------------------------------------|--------------------------------|---------------|---|
| Experiences outside of school context | People working in the industry | P.W.I | "My father is... an environmental inspector. Essentially what he does is to check the environment if it is clean and where necessary, he intervenes to maintain it. He controls water sources, forest, dams, biological stations, etc." (Student 5) |
| | Family holidays | Fam.Hol. | "...every 1st of May, we used to visit the countryside, where we came close to nature and had a picnic. My friends and I explored the place, played in the river and picked flowers to make a traditional wreath. We had a really good time there." (Student 1) |
| | Out of school activities | Out. Sch.Act. | "...I like to visit museums and nature. I like to observe how nature changes according to the seasons. I also like to watch documentaries related to nature... I visit many museums with my parents..." (Student 7) |
| | Love for nature | Lo.Na. | "I like nature a lot. I like to walk in natural trails and enjoy everything around me." (Student 11) |

Table 2 continued

| | | | |
|----------------------|------------------------------------|-------------|---|
| Experience in school | Elementary School | El.Sch. | “...in the elementary school we didn’t have experiment in every lesson. Most of the time we used the book to cover school curricula.” (Student 8) |
| | Teacher’s role - Elementary School | T.R.El.Sch. | “The teacher that I always have in my mind is the one I had when I was 3rd Grade. I always said that I want to be like him. and to be so much fun with my future students. ...our teacher was very devoted to his lesson and had a lot of knowledge, so his lesson never became boring.” (Student 14) |
| | High School | Hi.Sch. | “In High school all lessons related to science did not interest me... One time I had chosen to attend Biology but when I went to the lesson on the first day I didn’t like at all and the next day I went and changed it.” (Student 3) |
| | Teacher’s role - High School | T.R.Hi.Sch. | “...as our teacher was a professor who was old and did only theoretical lessons, we never experimented. He followed the curriculum material alone and with students who were ‘clever’ enough.” (Student 4) |

Findings

The analysis of the data showed that through their engagement in the science methods course, the participants developed more sophisticated personal philosophies about science teaching and learning. In their autobiographies, final exams and interviews before and after school experience, participants were asked to describe themselves while teaching science in the future. The main themes that emerged following on the analysis of the participants’ personal philosophies are presented below, under four sections: teaching conditions, teaching methods, teacher’s role and students’ feelings.

Teaching conditions

In their autobiographies, the participants referred to the nature of their teaching environment and issues related to classroom arrangement. For example, student 1 stated:

A friendly environment... an escape from the typical layout of the desks ...students will move according to the

requirements and needs of every activity. (autobiographies)

They also wrote about these issues in their lessons. For example, student 5 imagined that his lessons stand out of the typical lessons.

...escape from routine. ...unpredictable, creative and experiential lessons imprinted in their memory and knowledge that they will never forget. It will be adapted according to students’ educational needs. (autobiographies)

Four participants mentioned that their teaching will not only be confined within classroom, but on the contrary, that they will use different places. Student 2 wrote:

...I am going to use school yard, parks, sea, mountains, places that I can take students and study, investigate and learn... (autobiographies)

Three other participants stated that they would use a combination of materials from different disciplines.

One of them, student 16 stated:

...we are going to use teaching materials such as music, historical sources, stories, fairy tales, etc. (autobiographies)

Furthermore, some participants said that they are going to use technology in their lesson plans. For example, student 5 wrote:

By using technology, we will travel to places and see everything that we do not have the opportunity to see... (autobiographies)

Similar references are also identified through their final examinations. They want to teach science in a practical way. For example, one of the students, student 4 stated:

Science must always be done as practically as possible. ...we will make our lesson pleasant and creative. (final examinations)

Two participants also stated that the playful character of science teaching and learning is important. Student 12 wrote:

Science must have a playful character. Science becomes a game and you learn through it. (final examinations)

Also, three participants said that they would like to help students acquire knowledge and skills that can be useful to them for the rest of their lives. One of them, student 6 stated:

...it will enrich students with knowledge and skills that are useful and necessary throughout their life. ...skills such as critical thinking,

observation, cooperation, etc. (final examinations)

Some others would like to offer students rich life experiences, to help them understand the usefulness of science in life. For example, student 2 wrote:

I want to help them combine science with reality, to see that nature has its social character and its human dimension, that it is our everyday life. (final examinations)

In addition, they wrote about various elements which they considered important for science teaching. For example, student 8 stated:

...scientific thinking is the essence of science teaching... Interaction, creativity, innovation, respect are all necessary. (final examinations)

Similar ideas were also found in the participants' interviews before their school experience. Two participants said that they want to arrange visits in educational places and give students the chance to conduct experiments. For example, student 5 said:

...to make experiments. ...to visit a place with students, to explore. (interviews before school experience)

They also mentioned that they would like to help students cultivate leadership skills and to take initiatives. Student 8 said:

...students take initiatives and gain leadership skills in scientific research processes... (interviews before school experience)

The same descriptions are also found by means of their interviews after school experience. All participants

expressed the vision of teaching science outside the classroom. One of them, student 2 stated:

...out in the environment... outdoors in everyday life to explore. Students' role will be to be little explorers. (interviews after school experience)

Two of them said that they were going to have vitality, energy, take initiative and conduct experiments. For example, student 5 said: "Students will be engaged energetic, take initiatives... do experiments..." (interviews after school experience).

What becomes evidenced in the analysis of the interviews, the autobiographies, and the final examination results is a consistency among the participants' responses highlighting certain aspects related to how they envision the 'teaching conditions' as future teachers.

Advantages of the use of informal science approaches: Through the analysis of the participants' journals, it becomes obvious that the participants emphasized the value of implementing informal science approaches for the purpose of motivating students to engage with science and support their learning. The participants highlighted that informal learning is experiential because students discover knowledge on their own. For example, student 1 stated:

"They seek and discover knowledge on their own. Every student has the chance to enrich their knowledge according to their personal interest." (journals)

Also, the participants emphasised that informal science approaches might cultivate certain skills and

help students overcome stereotypes about science. As student 6 wrote: "Students overcomes stereotypes and cultivate knowledge and skills." (journals)

Alongside, participants said that all students have equal opportunities in learning through informal science approaches regardless of their social positioning. One of them wrote:

"...offers equal opportunities for all! ...opportunities at different levels of intelligence, even to people with special educational needs." (student 2, journals)

Furthermore, they wrote that informal learning presents the fun side of science and inspires students. For example, student 13 stated: "...it can inspire, and present the fun side of science..." (journals)

Similarly, participants expressed themselves in their final exams. Student 8 wrote:

"...they gain a lot, such as scientific knowledge, critical thinking and joy." (final examinations)

Similar findings were revealed through the analysis of the participants' interviews. They believe that because of informal learning students can love science. Student 2 said: "Definitely they will love science... initiate their interest, their critical thinking..." (interviews). As student 5 emphasised, this is because informal learning helps science to acquire a more playful form. "All this can be achieved because science involves play during learning." (interviews). Beyond the advantages of informal science approaches regarding student engagement, the participants also referred to advantages regarding teachers' work. More specifically, they wrote in their journals about how important the collaboration between teachers,

practitioners, and scientists is. For example, student 14 stated:

... they can help because they have specialised knowledge about certain issues, which helps teachers to enrich their teaching repertoire and offer their students more diverse learning experiences... (journals)

Similar views were expressed in the interviews. For example, student 2 said:

I believe that they support teachers' work...we need the help of experts to enhance students' learning. (interviews)

The findings show that participants realized the significant role of informal learning and they identified several advantages that relate to the utilization of out-of-school settings in teaching and learning.

Instructional practices

During the school experience, three participants tried to implement various informal science activities in their own teaching and tried to make connections between school science and students' experiences. Data collected through classroom observations during the field experience showed that the participants were able to make connections between the lesson and the students' lives. For example, student 8 taught electricity and started with a whole classroom discussion about the purposeful destruction of school property. Student 8 started the lesson with the following words:

Yesterday, when we came back from the holidays, we noticed that a lot of things in the school-yard were broken and others were stolen. At schools, we should find a solution to

face that problem and stop incidents of vandalism.

Students showed a lot of interest in solving this problem. They remained enthusiastic and listened carefully to what their classmates were saying. ...a student suggested increasing the lighting in the school yard. The teacher showed enthusiasm and said "...in this lesson we are going to learn about electricity so we can try to solve this problem." (observation, student 8, 25/4/2017)

Moreover, the analysis of the data showed that the participants also included collaborative learning in their instructional practices. For example, student 5 showed students map examples and explained to them how to make a map memo. Then he asked them to collaborate in their groups to map the artificial forest of their school.

He showed each group the area they needed to map. The teams proceeded to the places assigned to them and started to work to carry out the activity. (observation, student 5, 28/4/2017)

The participants implemented inquiry-based approaches in out-of-school settings in their teaching practices. For example, student 2 took students outside the classroom to carry out experiments.

They went to the schoolyard. He helped them to switch on the taps to the correct position. He said "wait and see how full the glass will be within 5 minutes." The students watched the glasses. They talked to each other about the possible results of their investigation... He said "see how much water we would be

wasting if we let the tap run for only 5 minutes! (observation, student 2, 26/4/2017)

Experiential learning was also an approach that was used by the participants. In a lesson about electricity that we observed, we observed students being engaged in various experiments:

Student 8 asked a student to approach and switch off the lights. He asked the student “what do you notice?” A student 8 said: “only five lamps are switched off”. He asked the student to switch off the other switch and then asked the same question. A student said that the rest of the lamps switched off. He asked “what is going to happen when a lamp stops working? Do all the lamps stop working?” A student said “no”. He asked “so what type of electricity circuits do we have in our classroom?”...Students agreed that it is a parallel circuit and they explained why. (observation, student 8, 25/4/2017)

Cross-linking is a practice that was also found in the observations we have made. For example, student 2, instead of using the textbook, used two different narratives, which he connected in a specific way to achieve his teaching purpose, and also dramatised a part of it. The following text shows the combination of narrative and dramatisation that he used.

While he was talking, he changed how he looked by wearing a shirt, hat and sunglasses. He changed his voice and while holding some pictures, he started reading what the

protagonist said. (observation, student 2, 26/4/2017)

Finally, all participants differentiated the learning environment in which their lesson was conducted. For example, student 5 chose to take students outside the classroom. He used the forest in the school yard to strengthen the achievement of his lesson’s goals. He said:

Now we will go to the forest in our school yard. We are going to see it and try to figure out if it is an artificial or natural forest. (observation, student 5, 28/4/2017)

In summing up, the above, the analysis of the data (journals, lesson plans, final exams, and interviews, observations) show that while the participants had developed contemporary ideas about science teaching and learning, they were not apply those in their instructional practices during their field experience.

Discussion and Conclusions

The findings of this study show how the participants’ personal philosophies about science teaching were influenced by their experiences as part of the science methods course during their teacher preparation and especially because of their engagement in the three informal science events. In terms of the participants’ personal philosophies about science teaching, we noticed that they referred to reform-based instruction approaches that emphasized inquiry based learning. Interestingly, the participants also highlighted the importance of utilizing out-of-school settings and adopting informal science approaches to science teaching and learning for the purpose of making strong connections between school science and students’ everyday lives, making science fun, motivating, and

engaging students in the activities. The significant role of informal science on teachers' learning and development has been revealed through a number of studies in the past two decades (Avraamidou, 2014; Kiesel, 2012; Melber & Cox-Petersen, 2005; Olson, Cox-Petersen & McComas, 2001; Riedinger, Marbach-Ad, McGinnis et al., 2010). As apparent in the findings, the participant's main goal, as future teachers, as preservice teachers stated was to offer students a set of positive and impactful experiences with science, which some of them did not have growing up. The findings showed that the participants highlighted the importance of the role they will adopt as teachers in order to be able to positively influence their future students. Their main goal, as articulated through their assignments, is to support students in developing positive attitudes towards science and better understanding its nature and value to the society. To achieve this goal, as the participants stated they

would implement reform-based approaches in science teaching. Similar findings were revealed in Avraamidou's (2015; 2016) studies, where the participants' personal philosophies of science teaching were shaped through their engagement in a reform-based science methods course. Regarding the implementation of informal science activities, the findings illustrated that they participants had difficulties in planning and enacting informal science approaches in their own practices, despite their efforts to do so. Despite the fact that the participants were able to design lesson plans that incorporated aspects of informal science approaches (e.g., science fair) in actuality they failed to enact those anywhere else other than the schoolyard. This points to the need for better supporting preservice elementary teachers in designing, planning, organizing and enacting informal science approaches in their own practices.

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